STANFORD RSL TECH REPORT #67-2

"FIELD INFRARED ANALYSIS OF TERRAIN
- SPECTRAL CORRELATION PROGRAM"

PART II - Stanford Adaptation and Corrections for Use on LMSC Program on IBM 7090 - 32K Memory Computer

and

PART III - Voltage Drift Correction Procedures

Already Issued

PART I - Original LMSC SG-4 Program Univac 1107 (February 8,1967) SRSL Tech Report #67-1

In Preparation

PART IV - Completed Stanford SG-4 Program - IBM 7090

PART V - Filter Wheel Spectral Program for Rapid Scan Spectrometer (IBM 360/50)

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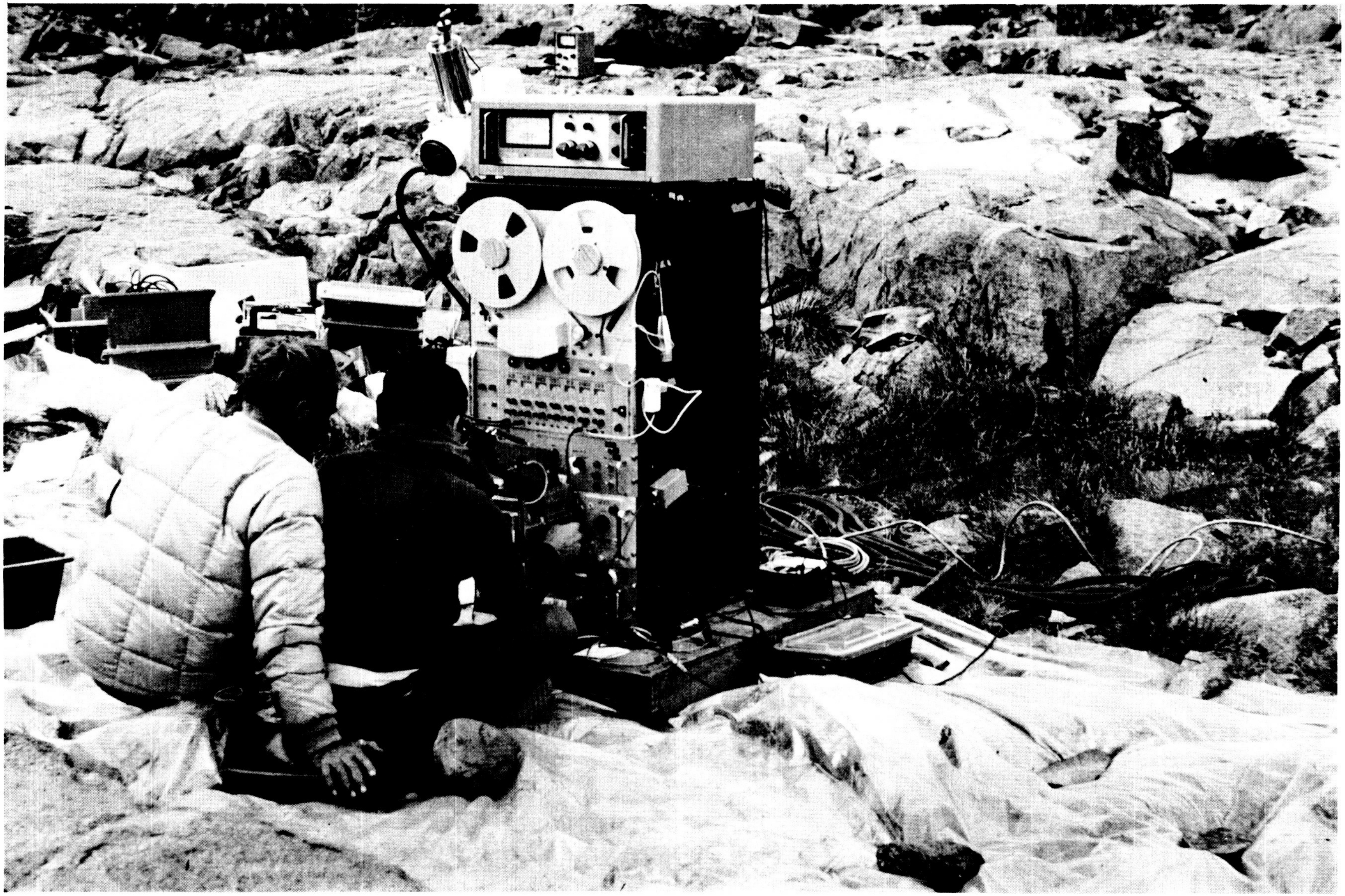
GENERAL PROGRAM DESCRIPTION - SG-4 INSTRUMENT

In the field seven channels of data are recorded in analog form simultaneously on AMPEX SP300 tape recorder. Separate channels allotted to various data are typically (but not always) as follows:

Track 1. Spectrometer radiance output (narrow-band)
2. Spectrometer radiance output (wide-band)
3. Spectrometer wavelength output
4. Radiometer (Huggins MKIX) total flux output
5. Spectrometer filter channel used
6. 12.5 Kc crystal oscillator signal (for flutter compensation)
7. Voice channel

Upon return from the field the analog tape is copied for preservation. The analog tape is played back at 4x recording speed (4 x 12.5 = 50 Kc=Channel 6) and then encoded with range coded time, defluttered electronically (forcing channel 6 to be a standard 50Kc signal) and a DUB analog copy tape prepared. The DUB is then run on an oscillograph to make a paper scroll record. Finally the DUB is sent to the A-D connector to be digitized in a TRIFID format.

The TRIFID data tapes are written in a closely packed binary form. As indicated previously, 3 words of wavelength and radiance are packed into one computer word. The TRIFID tapes are also blocked, that is 255 computer words are written onto one physical record of the tape. An inter-record gap occurs on the tape between each of these physical records. The last word of each physical record contains a range-coded time (Pacific Missile Range Time). It is assumed, to relate the wavelengths and radiances to a unique time, that each set of one wavelength observation and one radiance observation occurs at a time computed by a linear interpolation between the two range coded times of two successive records. Thus 254 computer words of packed wavelength



DATA RECORDING EQUIPMENT IN USE AT SONORA PASS TEST SITE

STATISTICAL INFORMATION TPOP01 NASA SPECTRA TAPE 0700 RUN 10-17-66

706 TPOP01 CX GRANITE ACROSS VALLEY (2000') *6 TEST NUMBER 000000000000

INTERVAL NUMBER 6 E (LAMBDA) BAR = 0.6905984E 00 VARIANCE E (LAMBDA) = 0.1603643E-02

LIBRARY SPECTRA		CORRELATION COEFFICIENT	CO-VARIANCE	E BAR (LIB)	VARIANCE E (LIB)
Q.M.P. ROUGH (NTS)	400031	0.97369256E 00	0.26884429E-02	0.81101153E 00	0.47539027E-02
GRANITE ROUGH	421331	0.96835477E 00	0.36676242E-02	0.87909526E 00	0.89452608E-02
WELDED TUFF (NTS-RAINIER)	400031	0.96345377E 00	0.13373988E-02	0.75537666E 00	0.12015793E-02
DACITE SAWN	431521	0.96286719E 00	0.20294635E-02	0.91276035E 00	0.27702698E-02
QUARTZ BEACH SAND	211243	0.95227173E 00	0.27635935E-02	0.80342085E 00	0.52519293E-02
GRANITE APLITE VEIN (SHOAL)	400031	0.94865768E 00	0.39142968E-02	0.75483248E 00	0.10616486E-01
PYROX APLITE	431231	0.94755526E 00	0.21414773E-02	0.83991386E 00	0.31850056E-02
CHERT (WITTENOOM) ROUGH	211133	0.92913143E 00	0.46281707E-02	0.84359061E 00	0.15472368E-01
QUARTZ X-CUT ROUGH	211130	0.92904866E 00	0.39123738E-02	0.82210688E 00	0.11058497E-01
QUARTZ X-CUT POL- ISHED	211110	0.92317742E 00	0.86648918E-02	0.73659994E 00	0.54934893E-01
TRACHYTE (ROUGH)	423731	0.90155987E 00	0.16122473E-02	0.85728827E 00	0.19941898E-02
TEKTITE	388821	0.89015909E 00	0.20793736E-02	0.73644178E 00	0.34026881E-02
GRANITE GNEISS ROUGH	421331	0.88848187E 00	0.20093572E-02	0.86889758E 00	0.31894037E-02
RHYOLITE PUMICE (V FROTHY)	438831	0.88566212E 00	0.13375219E-02	0.87008363E 00	0.14221912E-02
GRAPHIC GRANITE ACROSS GR.	421731	0.87556277E 00	0.31083615E-02	0.85754641E 00	0.78592448E-02
OBSIDIAN - 3424	488821	0.87094110E 00	0.15222116E-02	0.71633247E 00	0.19048677E-02
OBSIDIAN - 3365	488821	0.85309923E 00	0.13562691E-02	0.79336968E 00	0.15761044E-02
PLAG. BASALT ROUGH	634231	0.82723571E 00	0.12120288E-02	0.85379525E 00	0.13386274E-02
H. ANDES VITRO	534831	0.81436798E 00	0.16154136E-02	0.82260921E 00	0.24536829E-02
RHYOLITE PUMICE SAWN	434831	0.81296425E 00	0.70336039E-03	0.83864873E 00	0.46677251E-03
AUGITE DIORITE	634121	0.81254726E 00	0.10444987E-02	0.82825805E 00	0.10304119E-02
NEPHELINE SYENITE	532031	0.76693591E 00	0.21942275E-02	0.86944406E 00	0.51043153E-02
QUARTZ BASALT SAWNPOROUS	534621	0.71423221E 00	0.96237823E-03	0.72504644E 00	0.11321529E-02
AUG. DIORITE ROUGH	532421	0.70797863E 00	0.13706286E-02	0.83690222E 00	0.23371772E-02
QUARTZ SYENITE SMOOTH	523121	0.70707814E 00	0.19348526E-02	0.84319293E 00	0.46693163E-02
GARNET	634022	0.70574555E 00	0.78482833E-03	0.80184874E 00	0.77116158E-03
M.Q.S. SCHIST ALONG GR.	671032	0.68671916E 00	0.16549812E-02	0.85092316E 00	0.36217638E-02
MONCHIQUITE	640631	0.67896153E 00	0.11639812E-02	0.83355106E 00	0.18327109E-02
ANDESITE	523431	0.61261045E 00	0.77961289E-03	0.76470921E 00	0.10099074E-02
HYP. ANDES	534821	0.58448285E 00	0.66797065E-03	0.77409061E 00	0.81444837E-03
ANHYDRITE SAND	100040	0.56380793E 00	0.59294375E-03	0.83153013E 00	0.68969485E-03
DIABASE	634221	0.52234443E 00	0.61407573E-03	0.82028363E 00	0.86183131E-03
QUARTZ DIORITE	552131	0.48271875E 00	0.85628557E-03	0.90977197E 00	0.19621909E-02
NEPH. BASALT ROUGHPITTED	764031	0.47840763E 00	0.86503166E-03	0.88871384E 00	0.20387321E-02
K-FELDSPAR ROUGH CLEAVAGE	522220	0.46489677E 00	0.17077923E-02	0.78650688E 00	0.84149084E-02
BASALT	643631	0.38807067E 00	0.34650052E-03	0.68117899E 00	0.49713975E-03
OLIVINE GABBRO	735621	0.35144284E 00	0.43217858E-03	0.81809526E 00	0.94299510E-03
POLYSTYRENE STD.	900000	0.29290722E 00	0.17156744E-02	0.59551156E 00	0.21394491E-01
CALCITE	099910	0.13670082E 00	0.18511901E-03	0.77479527E 00	0.11435419E-02
SERPENTINE	730631	0.12522651E 00	0.28382426E-03	0.85261387E 00	0.32033090E-02
LEEDEY METEORITE	864322	0.72103220E-01	0.10182812E-03	0.75839293E 00	0.12437082E-02
HORN. GABBRO GNEISS SAWN	653022	-0.17110317E-01	-0.32886205E-04	0.80129293E 00	0.23035822E-02
METEORITE LADDER CREEK	864322	-0.33469796E 00	-0.23700019E-03	0.75293944E 00	0.31266812E-03
PERIDOTITE SAWN	746321	-0.34036493E 00	-0.67086846E-03	0.86940689E 00	0.24225765E-02
DUNITE GRIT (+850 MIC.)	766640	-0.42435645E 00	-0.49990077E-03	0.78141386E 00	0.86536301E-03
LIMBURGITE	767431	-0.43254008E 00	-0.79999716E-03	0.81407201E 00	0.21331261E-02
DUNITE ROUGH WITH SAND	766640	-0.46359276E 00	-0.57416586E-03	0.75306271E 00	0.95651938E-03
DUNITE POLISHED	766610	-0.50918773E 00	-0.23704359E-02	0.68853015E 00	0.13514281E-01
DUNITE ROUGH	766631	-0.53647120E 00	-0.13769182E-02	0.78314176E 00	0.41078618E-02
FARMINGTON METEOR-ITE	864322	-0.55509164E 00	-0.12540803E-02	0.85568360E 00	0.31828316E-02

TYPICAL PAGE OF COMPUTER OUTPUT SHOWING ANALYSIS OF FIELD SPECTRA OF QUARTZ MONZONITE TAKEN AT A HORIZONTAL RANGE OF 2,000 FT.

and radiance,plus one time,occur per record. This gives 254 x 3 or 762 words of wavelength and radiance or 381 sets of observations per record. These observations occur continuously and successively down the tape. In order to find a particular spectrum, two range coded times are required - the start of the spectrum and the stop of the spectrum.

The spectrum is found by searching the tape until a range coded time in the last word of a record exceeds a start time. If so the record is saved and the start wavelength and radiance are found by interpolation between this range coded time and the range coded time of the previous record.

Difficulty was encountered in determining the start and stop times of spectra. The computer program uses the information directly from the TRIFID tapes which were digitized from the original field analog tapes. This time information, because of noise, may not neccessarily agree with that on analog scrolls which were used previously to manually determine range-coded times. In addition the analog scrolls were hard to read with precision since the observer had to perform interpretive measurements which were subject to error in order to determine the start-stop times.

PART II

STANFORD ADAPTATION AND CORRECTIONS FOR USE ON LMSC PROGRAM ON IBM 7090 - 32K MEMORY COMPUTER

A. Introduction

In February 1966, the spectral correlation program was released to the Stanford Remote Sensing Laboratory by Lockheed Missiles and Space Company (LMSC) of Sunnyvale, California. This report* describes the modifications on that program which were necessary to implement it on the IBM 7090 at Stanford University. It also summarizes some of the improvements which were made during the course of the modification.

The program, as released, is described in LMSC Report #668744.** It was originally developed and run on the UNIVAC 1108. The basic program was written in FORTRAN IV. The original program utilized a UNIVAC machine language coded search package, however, an equivalent search package was made available in MAP to be used on the IBM 7090. Some changes were required to incorporate the MAP coded search package into the FORTRAN IV program and to implement it on the Stanford system.

B. Initial Improvements and Changes

1. Memory Space Conserved

Since this program was developed for a computer with more memory space than is available on the 32K IBM 7090 at Stanford University, certain changes needed to be made to reduce the amount of memory required.

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*This report is designated #67-2. Additional copies of all SRSL reports are available from the NASA-MSC Data Bank.

**Now Stanford Report SRSL 67-1.

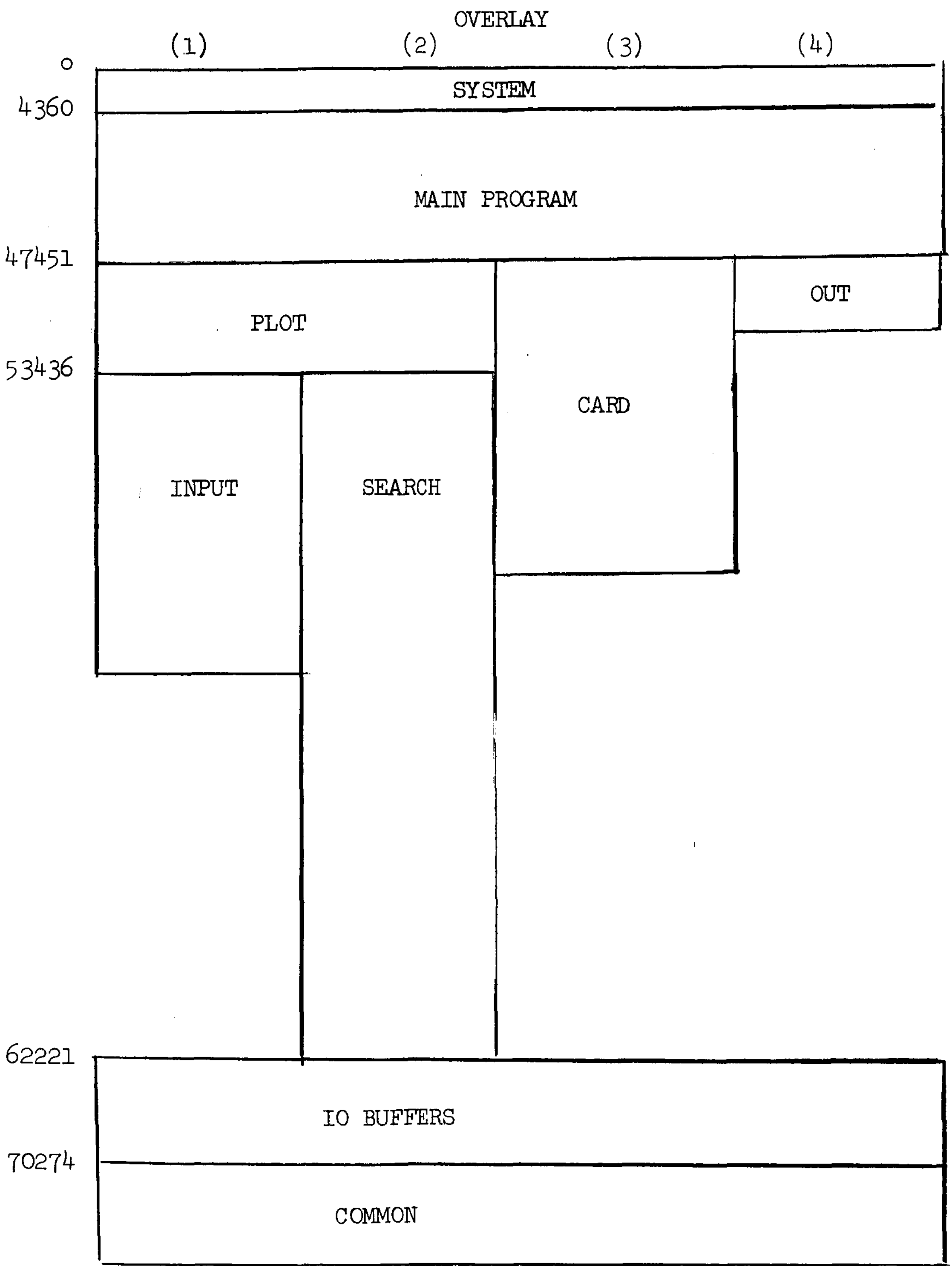
From prior usage it was determined that certain of the variable arrays could be cut down in size without greatly restricting the capability of the program. The following arrays sizes were altered:

VARIABLES	LOCKHEED SIZE	STANFORD SIZE
ARAY	100	20
BRAY	100	20
CRAY	100	20
DRAY	100	20
BUFFR1	3000	550
BUFFR2	3000	550
E	3000	550
EA	300 x 10	300 x 4
EB	3000	550
EINT	53 x 10	53 x 4
LAM	3000	550
LAMA	300 x 10	300 x 4
LAMB	3000	550
T	3000	550
TIME	3000	550

Definitions of these variables are given in LMSC Report* 668744. With the above changes the maximum number of black body intervals that can be averaged is reduced from ten down to four. This is the only significant restriction introduced by these changes.

The FORTRAN IV overlay feature was also incorporated to save storage space. The present method is to use four different overlay configurations as follows:

*Now SRSL #67-1


OVERLAY
(1)
(2)
(3)
(4)
0
SYSTEM
4360
MAIN PROGRAM
47451
PLOT
CARD
OUT
53436
INPUT
SEARCH
62221
IO BUFFERS
70274
COMMON

2. Input/Output Compatibility

Part of the search package used by this program consists of MAP coded input/output routines which were developed to enable rapid searching of data on magnetic tapes. One of these routines (OPENIO) performs the function of assigning logical tape numbers to physical tape units. The assignment of numbers to units is generally not the same from one computer installation to another. Hence in implementing this program at Stanford this assignment of tapes had to be changed to be consistent with the Stanford system. Further complication arose when it was discovered that the logic for assigning numbers to units was "machine dependent" on the Lockheed monitor system. In addition the unit control block (part of monitor system) of the Stanford system was somewhat different than Lockheed's because of the disc file on the Stanford machine. Hence new logic for tape assignments had to be programmed and debugged.

3. Conversion of Plotting to Calcomp System

The initial program included a facility for plotting black body radiance, average emittance and emittance ratio as a function of wavelength. Routines were included which generated plot information for the SC 4020. Since the Calcomp plotter is more readily available at Stanford the 4020 routines were replaced by equivalent Calcomp plot routines and a short subroutine, PPLOT, to call them. PPLOT performs the function of scaling data and calling in the proper plot routines to plot axes, labels and data points for average black body radiance, average emittance and/or emittance ratio (for each sample spectra) versus wavelength. The value of the variable KPLOT will determine which plots will be generated. In most cases the wavelength axes varies from 7.0 to 14.0 microns however, data over a different range can be plotted with proper specification of the input variable NSPEC.

4. Improvements in Output

The format of the output data was greatly improved with the addition of printed information describing each set of output and the grouping together of related data.

The facility for punching output information on cards is now also available. An initial identification card is punched for each run with information about tape number, run number, date, etc. Further card output is generated in groups of nine cards. The first card (data identification card) identifies the data in the following eight cards. Average blackbody radiance for each set of blackbodies and average emittance and emittance ratios for each sample spectra are punched on sets of eight cards. There are 53 values in each set with 7 values on each of seven cards (FORMAT(1X, 7F10.5))and four on the last card (FORMAT (1X, 4 F10.5)). Column 75 in each card contains a sequence number one through eight. Columns 76-80 contain an identification code. For blackbody radiance the first two code digits represent the tape number (if properly inputted), the third character is always a "B" and the last digit a sequence number for the set of blackbody data. In any run, blackbody data is always sequenced starting with one. For average emittance and emittance ratios the code number is the four digit sample spectra number.

The extreme values in correlation coefficients are also punched on cards, and used elsewhere in the "housekeeping" programs of the Remote Sensing Laboratories at Stanford

5. Error Messages

The initial version of the program gave a memory dump when certain errors were encountered during execution. However, there was no indication given as to the cause of the error or its point of occurence. This prompted the addition of error messages to be printed out when errors occur.

Error messages and their causes are given in Appendix B.

C. Program Bugs Detected and Corrected

1. Adaptation of the Search Package

The initial version of this program was being used on the UNIVAC 1108 with a machine dependent search procedure for finding start and stop times on the digital input tape. Since the search package was machine dependent it could not be used on the IBM 7090 at Stanford. Hence an equivalent 7090 search package had to be used. The incorporation of this new set of routines required the change of the main program calls to these routines and the introduction of four tape indicatives.

A considerable amount of effort was spent developing the correct linkage between the main program and the 7090 search package.

2. Buffer Dimensions Inconsistencies

One of the very early problems encountered in this program was a program halt during execution caused by a portion of the program being overlayed by data. The cause of this was due to the fact that the array BUFFER had been declared to be one size in one routine and a different size in another routine. The consistent dimensioning of the array BUFFER remedied this problem. The basic reason for this problem was that the main program and the search package were LMSC programs which were developed independently, and their compatability had not been checked out.

3. Indicative Flippings

Sometimes for an unknown reason the analog-to-digital converter changes the sync-bit (binary minus) location. A brief explanation of word packing and sync-bit is as follows. Three words of wavelength and radiance are packed into one computer word. The sync-bit (minus sign indicates which part of the computer word is the wavelength. In two successive computer words there are 3 wavelengths and 3 radiances. It was noted that sometimes this sync-bit changes location in the middle of a record. Logic is now in the program so that if this happens, the expected location of the sync-bit is flipped to the other channel, the tape rewound, and the calculation restarted from where it had stopped. This is not a general solution to the problem, because if the flipping occurs in the middle of a record which is to be read, the program after flipping will be unable to read the first part of the record.

Its usefulness is primarily when the indicatives were improperly specified initially, or if the flipping occurs between records which are to be read.

It was also noted that in some cases the wavelength value was taken to be the radiance value and vice versa. This resulted in an interpolation error when the calibrations of these two values were attempted. In particular, the wavelength value was found to be out of the range of the calibration table for radiance. This error is remedied by rerunning the data with the third and fourth indicatives interchanged. This then identifies the sync-bit with the correct data.

4. Initialization of Indices, I1 and I2

I1 and I2 are integers between 1 and 53. They refer to the library spectra input to the program. I1 = 1 at the low wavelength end of the spectra and increases by 1 for each entry in the library spectra table. The rock library has 53 entries. The program has quite a bit of logic built into it which is based on a library size of 53, thus all other library which one attempts to use or construct should also have 53 entries.

Now in the program, after the blackbody calculations are completed, I1 is the lowest wavelength entry in the blackbody spectrum and I2 the highest. Consider an example. Suppose the library spectrum goes from 7.8 microns to 13.0 microns in intervals of 0.1 microns. If the blackbody spectrum starts at 7.8 then I1 = 1; if the blackbody spectrum starts at 7.9 then I1 = 2 and so on. Similarly for I2, I2 = 53 when the blackbody spectrum stops at 13.0.

Now when an input spectrum is processed this spectrum may start and stop at wavelengths which may not correspond to the blackbody start-stop wavelengths. Thus I1 and I2 are peculiar to each input spectrum also.

Initially the program did not consider this possibility. It used I1 and I2 from the previous sample spectra rather than from the blackbody spectra. A change was made in the program so that the values I1 and I2 given by the blackbody calculation are saved. The initial values given to each input sample spectrum are reset to the correct blackbody numbers before each spectrum is processed.

5. Interpolation Changes Effected

The Lagrangian interpolation routine was developed with the assumption that the change in the wavelength values would be monotonic. Hence the first value in the array of wavelengths would be expected to be the smallest and the last value the largest, or vice versa.

The first thing that must be determined before each interpolation is whether or not the wavelength to be interpolated is within the range of the array of wavelengths. It is accomplished by comparing the wavelength to verify that it is larger than the first (assumed to be minimum) value in the array and smaller than the last (assumed to be maximum) value in the wavelength array.

Due to the noise present on some of the digital tapes (particularly tapes 8 and 9) the wavelength arrays were not monotonic. Hence, the first value in the array was not necessarily the minimum and the last value not necessarily the maximum. In this case a value larger than the last value in the array but smaller than the maximum value would be mistaken to be out of the range of the table. This condition automatically terminated the execution of the program with an error message (IERROR = 3).

This situation was remedied by changing the interpolation routine so that the value to be interpolated is compared with the maximum and minimum values in the array rather than the first and last.

D. Variable Sampling Rate Introduced.

One of the major changes made in the program NSCP was the incorporation of logic to automatically change the sampling rate of the data on the digitized input tape. This change was prompted by a problem encountered in running 1966 tape #11 (Davis, California, agricultural test site data), which was digitized with a higher rate than any of the prior tapes. The program is designed to search the input tape, to locate the specified starting time and to read in data starting at that time and continuing until the specified stop time is encountered. The problem arose when the array for storing data points (BUFFER) was filled up to its maximum size (550 memory words) before the stop time was reached. Hence the number of data points between the start and stop time was too large to be accommodated in the memory space allocated for its storage.

There were several ways to remedy this problem. One was to increase the array size of BUFFER, however, this was impossible due to Stanford 7090 storage limitations (32K words). Another way was to reduce the amount of data by reducing the time interval. A third way was to reduce the sampling rate of the data. This latter alternative was chosen.

The variable ISAMP in the subroutine SEARCH gives the value of the sampling rate. Initially ISAMP = 1, i.e., every point is sampled.

If the number of points read in exceeds the storage allocated, then ISAMP is increased to two and the data is read in again taking every other data point. Each time the storage is exceeded and ISAMP is incremented by one a message is printed out to inform the user of the current sampling rate. If ISAMP reaches a maximum of nine the run is terminated.

E. Comparison of Output Data with Previous Results

In order to verify the correctness of the program operating under the Stanford Computer System, the results were compared with those results obtained at the Lockheed Computer Installation.

One distinct inconsistency was noted. In particular for a given set of start and stop times the array of wavelengths found within that time interval was not the same as the array found in an identical Lockheed calculation made previously. Furthermore, the wavelengths were not monotonically increasing or decreasing with time. In several cases the maximum wavelength occurred a short time after the start time or just before the stop time, indicating that the start and stop times were chosen incorrectly. Yet the times were the same as those used previously. Hence it became apparent that the difference between the two runs resulted from different LMSC-generated input tapes. An investigation of the input tapes indicated that there were several versions of each digital input tape and that the tapes that we were using were not necessarily the same versions which were used at Lockheed.* In the development of the computer program, Lockheed had experienced some of the same troubles with "noisy" digital tapes. They had apparently remedied this problem by re-processing the tapes in one of two ways, 1) re-doing the complete analog-to-digital conversion with new dubbed times, or 2) smoothing the voltages by some method (method unknown) which did not affect the dubbed times.

*In all fairness to LMSC it should be noted that the original contract (NAS2-2529) under which this work was performed did not call for Ames or Stanford to receive digital tapes. These were provided by LMSC as a favor.

The following table contains the pertinent data regarding the digital tapes.

	TAPE USED AT STANFORD		TAPE USED AT LOCKHEED	
Tape No.	Lockheed Reel No.*	Date*	Lockheed Reel No.*	Date**
4	14641	10-14-65	14641	10-14-65
6	14656	10-14-65	No record	
7	10231	1-4-66	10231	1-4-66
8	no number	11-23-65	14184	11-23-65
9	14514	1-12-66	10235	1-28-66
10	75	1-25-66	75	1-25-66

* information obtained from tape reels at Stanford

** information obtained from Lockheed records of David Badal

The above table indicates that the tapes used at Stanford for 4, 7 and 10 were the most recent versions. Results of these tapes should compare favorably with Lockheed results. It is apparent that the tape for 9 is not the most recent and it is suspected that this is likewise the case for tape 8. Hence one can not expect to duplicate Lockheed's results now from these tapes. The tape for 6 contains an entirely different set of times than those used by Lockheed, indicating that a different tape was used.

The effect of these tape differences on the final correlations is difficult to determine. It is apparent, however, that noisy data, particularly non-monotonic wavelength data, causes serious problems in the interpolating routine which in turn results in bad points, which could significantly effect the correlations.

F. Summary of Processing Results

Due to the fact that we initiated the request* late in the contract period (Sept. 1965), only six digital tapes were able to be saved for us by Lockheed (tapes #4,6,7,8,9,10).

* See footnote preceding page.

TAPE 4

Tape 4 was run without serious problem except for samples 451, 452, and 453. For some undetermined reason the times for these samples could not be found on the tape.

TAPE 6

The input times that duplicate the Lockheed run of tape 6 were not the same as those present on the tape. The times used by Lockheed were in the neighborhood of "15 hours, 14 minutes", while the actual times on tape 6 (decoded from tape dump) were around "0 hours, 24 minutes." This indicates that tape 6 has been digitized twice with different dubbed times. In studying the Lockheed report on the computer program, a set of input data was found in a sample calculation which corresponded to the times present on tape 6. This data was used to successfully run sample 601-614 using tape 6.

TAPE 7

Tape 7 was run with two different sets of data. The first set, which duplicated the run made at Lockheed, was run successfully for all samples. The second set of data included start and stop times to give a maximum time interval. A problem arose when one of the blackbody time intervals produced bad data. It is believed that this was caused by erroneous data on tape 7. The elimination of this blackbody (i.e., using 3 blackbodies instead of 4) remedied the problem. This second run of tape 7 also prompted the detection of the program error of failing to initialize I1 and I2 for each sample (see sample 708). The shortness of sample 708 caused all successive samples to be truncated (I1 = 6, I2 = 28).

TAPE 8

There were no problems encountered in running the last half of tape 8, samples 815-822. The first part of tape 8 (samples 801-814) resulted in a non-monotonic blackbody wavelength array, which caused trouble in the interpolation routine for determining average blackbody radiance. The trouble was cured with the appropriate changes to the interpolation routine (see section E.5)

TAPE 9

The first part of tape 9 (samples 901-913) was run without difficulties. In running the second part (samples 914-934) the same problems that occurred with tape 8 were encountered. The same changes in the interpolation routine eliminated this problem.

TAPE 10

Tape 10 ran without difficulty.

TAPE 11 (1966-SU Data.)

In order to run tape 11 successfully the mecahnism for varying the sampling rate was needed. Also a library for low wavelength samples was required as well as some minro changes to the plot routine to plot lower wavelength values.

G. Bad Data Generated by Interpolation Routines

An interesting phenomenon was observed in the output from tape 8, which gave indication that the routine for four-point Lagrangian interpolation (INTERP) was not giving correct values. A further investigation of this confirmed it to be true that under certain conditions the interpolating did not give an accurate value.

In Fig. 1 the points from the array of wavelengths and the interpolated wavelength values are plotted on the horizontal axes and the corresponding radiance on the vertical exes. These points occurred in the second blackbody interval for tape 8 (start time 10h 7m 49.0s and stop time 10h 8m 0.5s).

Interpolated points are denoted by X, given points are dots. The numbered points (dots) designate the time sequence in which the points occurred. Note that the wavelength does not increase monotonically with time, e.g., the wavelength at point 12 is smaller than

FIGURE 1

$$\text{SLOPE} = \frac{Y_{12} - Y_{10}}{X_{12} - X_{10}} = \frac{0.24748167-0.24034492}{8.8660756-8.8659241} \approx 500$$

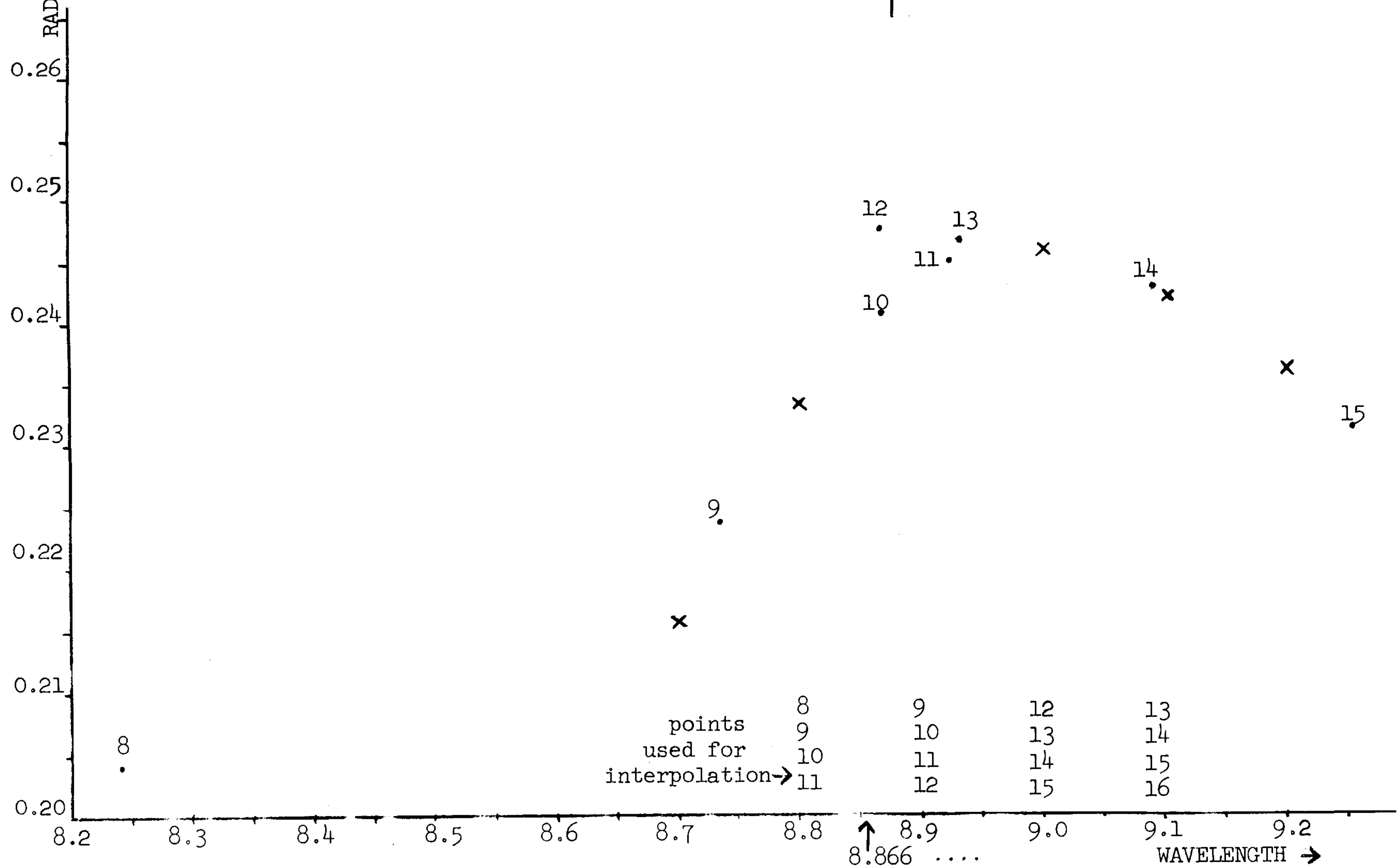


Figure 1

at point 11. The points used for interpolation are indicated along the wavelength axes at each interpolated point. For example, the radiance value for 8.8 microns was obtained from an interpolation polynomial defined by points 8,9,10 and 11.

The interpolated radiance value for 8.9 microns is around 1.1, whereas the four points used for interpolation (points 9, 10, 11 and 12) were all around 0.245. Here the interpolating polynomial based on these four points gives an incorrect radiance value for 8.9 microns. A close look at the four points in question suggests that a polynomial through those points would have a very sharp peak between points 11 and 12, due to the steep slope between points 10 and 12. A verification of this is shown in Fig. 2, where some additional points are given between 11 and 12 (X denotes an interpolated point) and the apparent interpolation polynomial is given by the dotted line. This is a prime example of how one bad (noisy) point, in this case point 12, can produce a significant error.

It is apparent in the case of tape 8 that this problem would not have occurred if the table of wavelengths were monotonically increasing and not so noisy. The elimination of noisy data would certainly correct occurrence of bad points from interpolation.

An alternative to this would be to replace the interpolation routine with one which uses a more satisfactory interpolation method such as a linear least squares fit on four points. Nevertheless the result would still be based on noisy data.

TAPE 8
8-14-66

Figure 2.

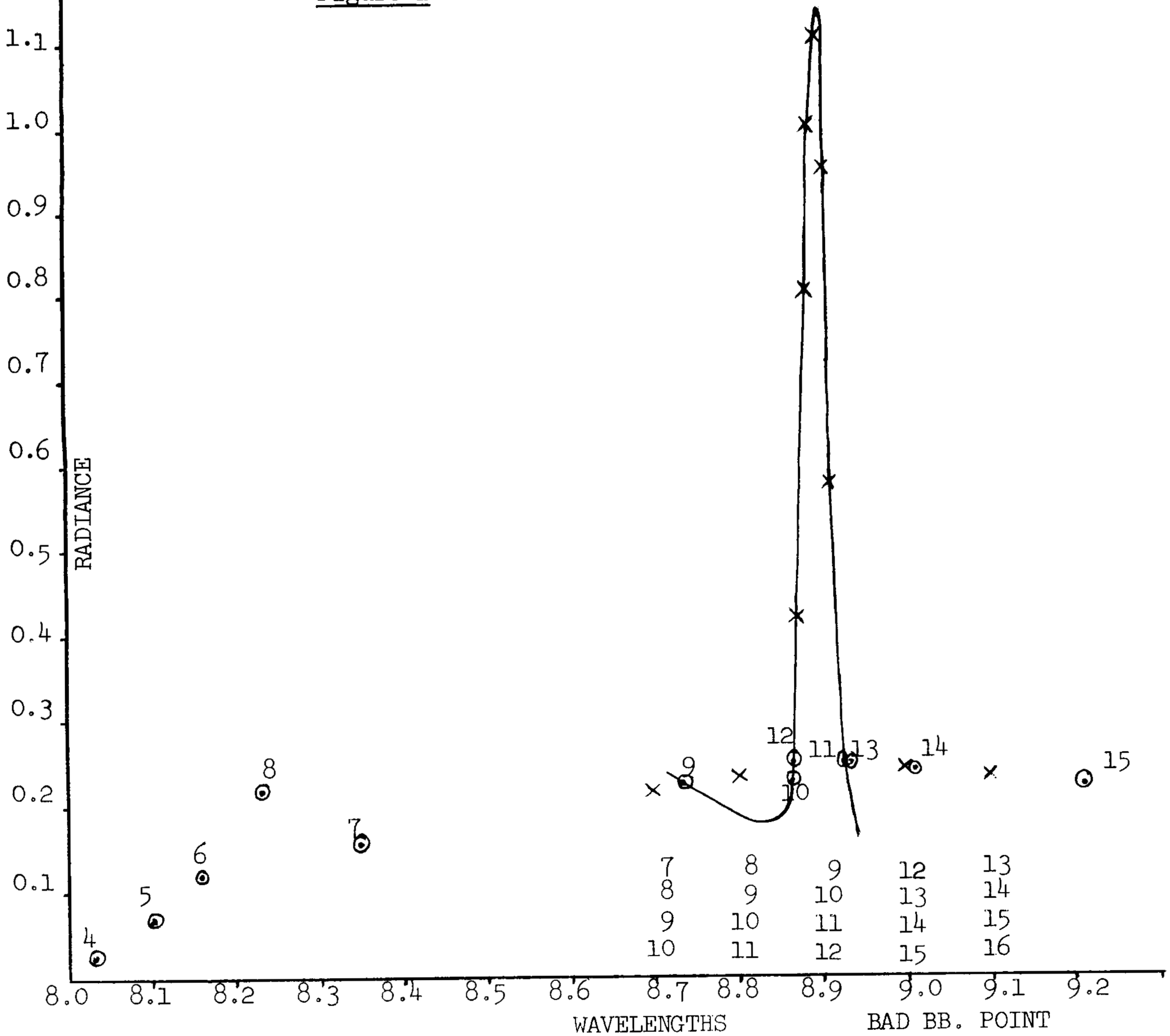


Figure 2

APPENDIX A - Data Card Formats

(1) Input Data

All times are specified in pairs, the first being the start time of an interval and the second being the stop time. Each time is specified in hours (H) with format I2, minutes (M) with format I2 or I3 and seconds with format F5.2, F6.2 or F7.2. See Format Sheet for details.

Card type A

NTAPE - logical tape number for the unit from which the digitized voltages are read. Note: generally NTAPE = 12 which is unit B7 on the Stanford system. Format (I5)

LIB - logical tape number for the unit from which the library spectra are read. Note: generally LIB = 9 which is unit A5 on the Stanford system (Format (I5)

N - should always be specified as one for the first set of data to allow the library tape to be read in. If other sets of data follow, N can be set equal to 2 to bypass the rereading of the library tape

KPLOT - for KPLOT = 0 no plots will be generated
for KPLOT = +1 plots of blackbody radiance and average emittance will be generated
for KPLOT = -1 plots of blackbody radiance and emittance ratio will be generated
for KPLOT = 2 plots of blackbody radiance, average emittance and emittance ratio will be generated (Format (I5)

NDEBUG - if NDEBUG > 0 intermediate data will be written out for debugging purposes Format (I5)

NSPEC - if NSPEC > 0 program logic for processing low wavelength data will be used. Format (I5)

WAVLOW - lowest wavelength at which the instrument will operate. Format (F10.4)

WAVHIG - highest wavelength at which the instrument will operate. Format (F10.4)

Card type B

VMAXWL - wavelength voltage level corresponding to the first time interval on the card. Format (F6.2)

VMINWL - wavelength voltage level corresponding to the second time interval on the card. Format (F6.2)

ITECS - temperature number should always be specified as one. Format (I4)

NIBB - number of black bodies to be averaged - note: $1 \leq \text{N1BB} \leq 4$ Format (I4)

NISSP - number of sample spectra to be processed. Format (I4)

Card type C

INDIC(1) and (2) - octal indicatives used to identify the input tape containing digitized voltages - these indicatives must match those on the first record of the tape. Format (012)

INDIC (3) and (4) - octal indicatives used to designate the position of the sinc bit and the number of channels of data on the digital voltage tape - these values are generally octal 1 and octal 2, specified in an order determined by the position of the sinc bit in the first word of the data.

NCRDS - number of cards required to specify the calibration table. Format (I6)

Card Type D

DTBB - length of the time interval in seconds divided by the number of points to be sampled in the interval (if this variable is left blank the program computes DTBB = time interval (seconds)/51. Format (F4.2)

Card Type E

VMAXIR - radiance voltage level corresponding to the first time interval on the card. Format (F6.2)

VMINIR - radiance voltage level corresponding to the second time interval on the card. Format (F6.2)

Card Type F

This card contains alpha numeric information for identifying the input data, eg. tape number, site run date, etc. Format (12A6) note: the site code is generally specified in columns 1-6.

Card Type G

DISSP - length of time interval in seconds divided by the number of points to be sampled in the interval (if left blank the program computes DISSP = time interval (seconds)/51. Format (F3.1)

Sample Code - six letter code designating the sample

Sample Number - four digit number identifying a sample - first two digits are often the tape number.

Site Code - six letter code designating the site.

Sample Description - any descriptive information about the sample

Card Type H

ARAY - calibration table voltage values for wavelength calibration Format (F6.2)

BRAY - calibration table corresponding wavelength values. Format (F6.2)

CRAY - calibration table voltage values for radiance calibration. Format (F6.2)

DRAY - calibration table corresponding for radiance calibration Format (F6.2)

(2) Deck Set-up

Data cards are read by the program in the following order:

Sequence	Type	Number of Cards
1	A	1
2	B	1
3	C	1
4	D	1 if NIBB=1 2 if NIBB=2 3 if NIBB=3 4 if NIBB=4
5	E	1
6	F	1
7	G	NISSP
8	H	NCRDS

APPENDIX B - Error Messages

(1) Search Errors

An error that occurs during the tape searching routine will terminate the execution of the program with a message indicating where the error occurred and a variable IERR whose value will indicate the cause of the error. The following values of IERR may occur:

IERR = 0	no cause for error is given
IERR = 1	incorrect indicative specified - usually means that the wrong tape was used
IERR = 2	unable to find start time in the first file - usually means that the start time was specified incorrectly
IERR = 3	no sync bit in frame - this is usually corrected by interchanging the third and fourth indicatives
IERR = 4	unable to find stop time in the first file - usually means that the stop time was incorrectly specified

The following messages may occur:

SEARCH ERROR IN FINDING WAVELENGTH CALIBRATE TIMES

SEARCH ERROR IN FINDING SAMPLE EMISSION SPECTRA CALIBRATE TIMES

SEARCH ERROR IN FINDING BLACKBODY TIME

SEARCH ERROR IN FINDING DRIFT CORRECTION TIMES

SEARCH ERROR IN FINDING SPECTRUM TIME

(2) Interpolation Errors

An error occurring in the interpolation routine will also cause the termination of program execution. A message is written out and a value for IERROR is given indicating the nature of the error. The following values of IERROR may occur:

IERROR = 1	no cause for error is given
IERROR = 2,3	value to be interpolated is out of the range of the interpolation table

The following messages may occur:

BB INTERP ERROR FOR A - B

BB INTERP ERROR FOR C - D

BB INTERP ERROR FOR LAMA-BASEL ARRAY

INTERP DRIFT ERROR

SPECTRUM A - B INTERP ERROR

SPECTRUM C - D INTERP ERROR

SPECTRUM INTERP ERROR FOR LAMB-BASEL ARRAY

Along with some of the above messages, intermediate data will be written out for debugging purposes.

PART III

VOLTAGE DRIFT CORRECTION PROCEDURE

A. Analysis of Voltage Drift Problem

The detailed study of the Lockheed digital tapes showed a clearly defined tape voltage drift which was sequential with time. Lockheed had generated the digital tapes from our original analog records during the course of the original NASA(ARC) - LMSC contract (NAS2-2529). After the conclusion of that contract, LMSC sent the remaining 6 of the 10 tapes to Stanford for further analysis by the Remote Sensing Laboratories.

This analysis of the data indicated that the power supply in our Ampex SP300 tape recorder was apparently out of adjustment for a 3-month period during the latter part of 1965. Unfortunately this was during our main data recording period. This asserted itself as drift on the voltage controlled oscillator (VCO), effectively changing all the voltages recorded on each of the 7 channels. The changes were cumulative from approximately August until the end of the field work in late October 1965. At this time the drift was approximately 10% out of calibration. One most frustrating characteristic of this drift was that it had a marked daily-rise character, but the instrument would revert to the previous level of drift upon switching off and cooling. The drift followed a varying pattern during August, but from September 22 to October 31, it approximated a negative 0.2 volts drift per month on the recordings. Superimposed on this, the daily drift was positive and of 0.10 volts per hour. This however disappeared during any cooling over 30 minutes. The instrument would then revert back to its original drift level of that particular morning.

The following points became significant in discussion of the correction method:

(a) All spectra taken with a grating instrument require an order-sorting, optical filter be placed in the optical train to avoid the superimposition of second- and third-order spectra on top of the first-order spectrum. Our #4 optical filter has, as its characteristic shape, a "cut-on" approximately at 8.2 microns, "half-power point" at 8.5 microns and "long-pass" out to beyond 12 microns (see Fig. 1). Significantly there is a bump of a higher transmission at exactly 10.0 microns. This is a filter characteristic and is therefore impressed on all radiance data obtained through this filter.

(b) Inspection of all the spectra produced on the X-Y oscilloscope (photographed as polaroid prints concurrently with the tape recordings) showed that this peak maintained its 10.0 micron position and pattern regardless of the time of the day or year in which the recording was made. This is to be expected, but is the confirmatory evidence needed to identify the malfunction as being in the tape recorder VCO system down-stream from the oscilloscope.

(c) For each field trip it is possible to determine a daily and hourly voltage shift of the ten-micron bump on the spectral radiance data.

(d) The drift could be corrected either by adjusting the position of this peak manually (a "data shift") or by recalibrating the start voltage using known "stop" and "start" wavelengths for the spectra. Both methods have been used.

A first attempt was made to correlate the drift with operating temperatures as we had spent the latter part of the field trips in

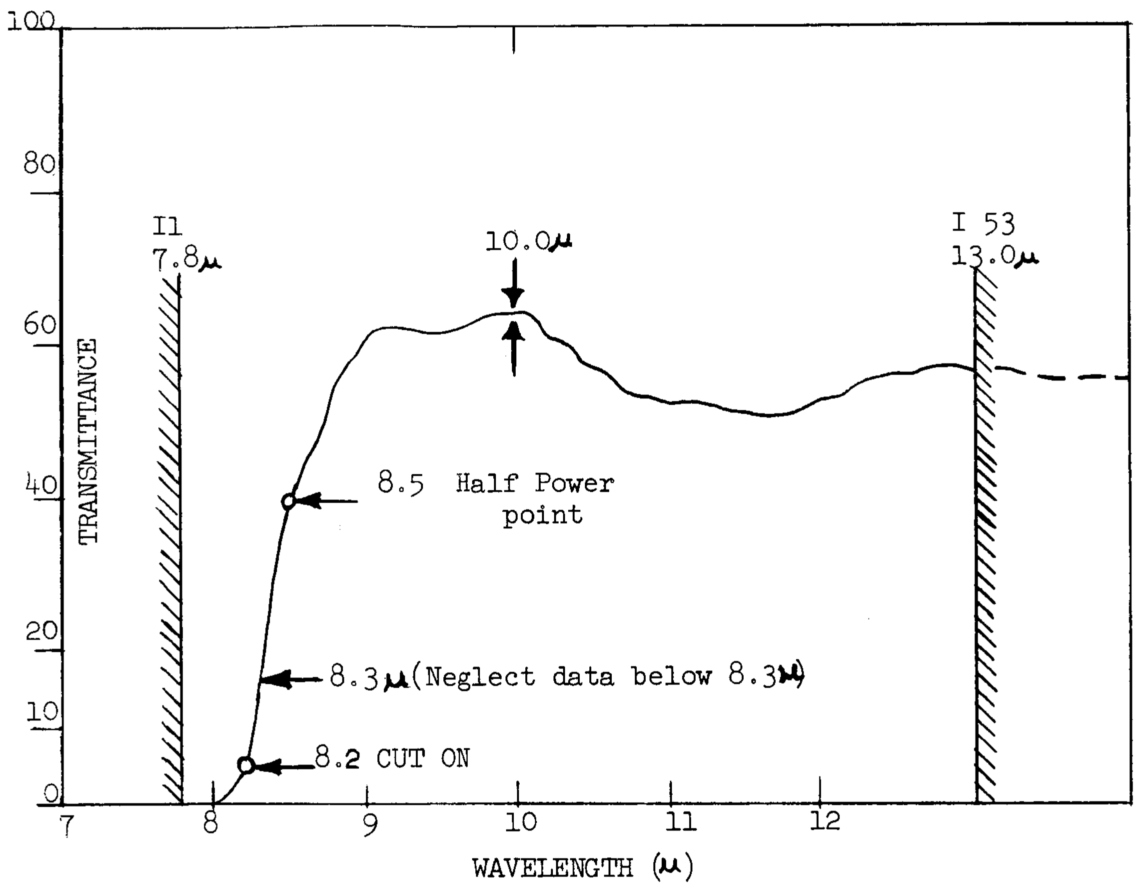


Fig.1 Shape of filter used for order-sorting and impressed on all 1965 field data. Note 10.0μ "bump" of slightly higher transmission.

the desert. Table I showed quickly that this correlation was usually negative, that is it was negative with respect to the outside air temperature. There was a close correlation with lapsed time or the number of minutes over which the equipment (mounted in the cab) had been turned on. A plot of the drift pattern i.e. value and sense positive or negative is shown in Fig. 2, where drift is plotted against date of operation - often positive and negative drifts are shown (Tape 6 - Day 277) for the same day, separated by a break (147 mins.) during which the equipment apparently cooled down.

A plot of the magnitude of the voltage drift (either +ve or -ve) versus lapse time (Fig. 3) shows an interesting relationship. Despite the spread of the data a crude value can be determined of 0.1 volts drift/hour at a 4.0 volt level. This is equivalent to an 0.25μ drift/hour, truly a discouraging fact in any system.

A similar analysis of Fig. 2 shows a negative drift of - 0.2 volts/month or approximately 0.5μ/month for the field data after tape 3.

Having now described the problem, let us explore the methods we have used to correct the effect in the data. Hardware corrections have been effected as follows:

1. Crystal controlled 12.5 Kc oscillator replaced the hand-set 12.5 Kc unit previously in use. Tape 11 (1966 data) was the first to use this and it gave excellent control.
2. The Ampex SP300 unit has been repaired and re-calibrated and most of the drift effects have been removed. (Some effects are still present, but appear to be SG-4 generated instead of tape recorder faults).

Tape No. - Day	Location	Drift(μ)	Correl. with rising air temp.	Lapsed mins. in/opn.	Work Stoppage Pattern-mins. [X(Break)Y(Break)]	Drift in Volts (true value is 3.87V)	ΔV	Change in air temp. during period $\Delta T^{\circ}C$
1 - 224	PGC401	9.3-9.1	- ve	110	[18(46)30(19)]	3.62-3.52	- .08	+1
2 - 225	PGLP01	9.4-9.3	- ve	54		36.3-35.9	- .04	+1
2 - 230	DP6C01	9.1-9.3	- ve	93	[27(20)3(21)22]	3.52-3.60	+ .08	-3
			38 days between tapes 2 and 3					
3 - 268	MCAB01	10.6-11.3	- ve	120		4.10-4.37	+ .27	-3
3 - 269	MCSC01	10.7-10.9	- ve	66	[8(20)37]	4.13-4.22	+ .09	-2
4 - 270	MCSC05	10.3-11.2	- ve	137	[23(15)15(35)40]	4.0 -4.34	+ .34	-8
4 - 271	MCNC01	10.5-11.0	- ve	117	[75(34)6]	4.07-4.27	+ .20	-3
4 - 274	MCNC01	10.6-11.3	+ ve	143	[16(82)45]	4.11-4.34	+ .23	+3
5 - 275	MCCC01	10.4-11.1	- ve	91	none	4.04-4.30	+ .26	-5
5 - 276	MCSC05	10.5-11.1	- ve	93	(31)	4.06-4.30	+ .24	-2
6 - 276	MCSC05	10.8-10.8	- ve	26	(52)	4.03-4.17	+ .14	-1
6 - 276	MCSC10	10.4-10.1	- ve	68	none	4.03-3.91	- .12	-3
6 - 277	MCSB01	10.5-11.3	+ ve	65	(147)	4.07-4.37	+ .30	+3
6 - 277	MCSF01	10.4-9.7	- ve	9	none	4.03-3.76	- .27	-1
			10 days between tapes 6 and 7					
7 - 287	TPOP01	10.3-9.9	- ve	119	[63(29)27]	4.00-3.93	- .17	+6
7 - 287	TPLD01	10.2-10.0	- ve	83				
8 - 288	MCBP01	10.3-10.1	- ve	111	[15(32)64]	4.00-3.91	- .09	-6
8 - 296	PCWR01	10.2-10.1	+ ve	52		3.96-3.90	- .06	-1
9 - 296	PCWR01/2	10.0-9.8	- ve	91	[46(11)34]	3.88-3.79	- .09	-3
9 - 297	PCTP01	10.0-11.1	+ ve	245	[82(72)31(30)30]	3.87-4.30	+ .43	+9
10 - 297	PCER01/2	10.1-10.1	≈	40		3.92	0	-7
10 - 298	PCLL12/ 13/14	10.1-10.2	≈	107	[78(4)25]	3.91-3.96	+ .05	-1
10 - 299	PCLL15	9.8-10.1	+ ve	37		3.80-3.91	+ .11	+3

TABLE I Correlation of Drift with Outside Air Temperature & Lapsed Time in Operation

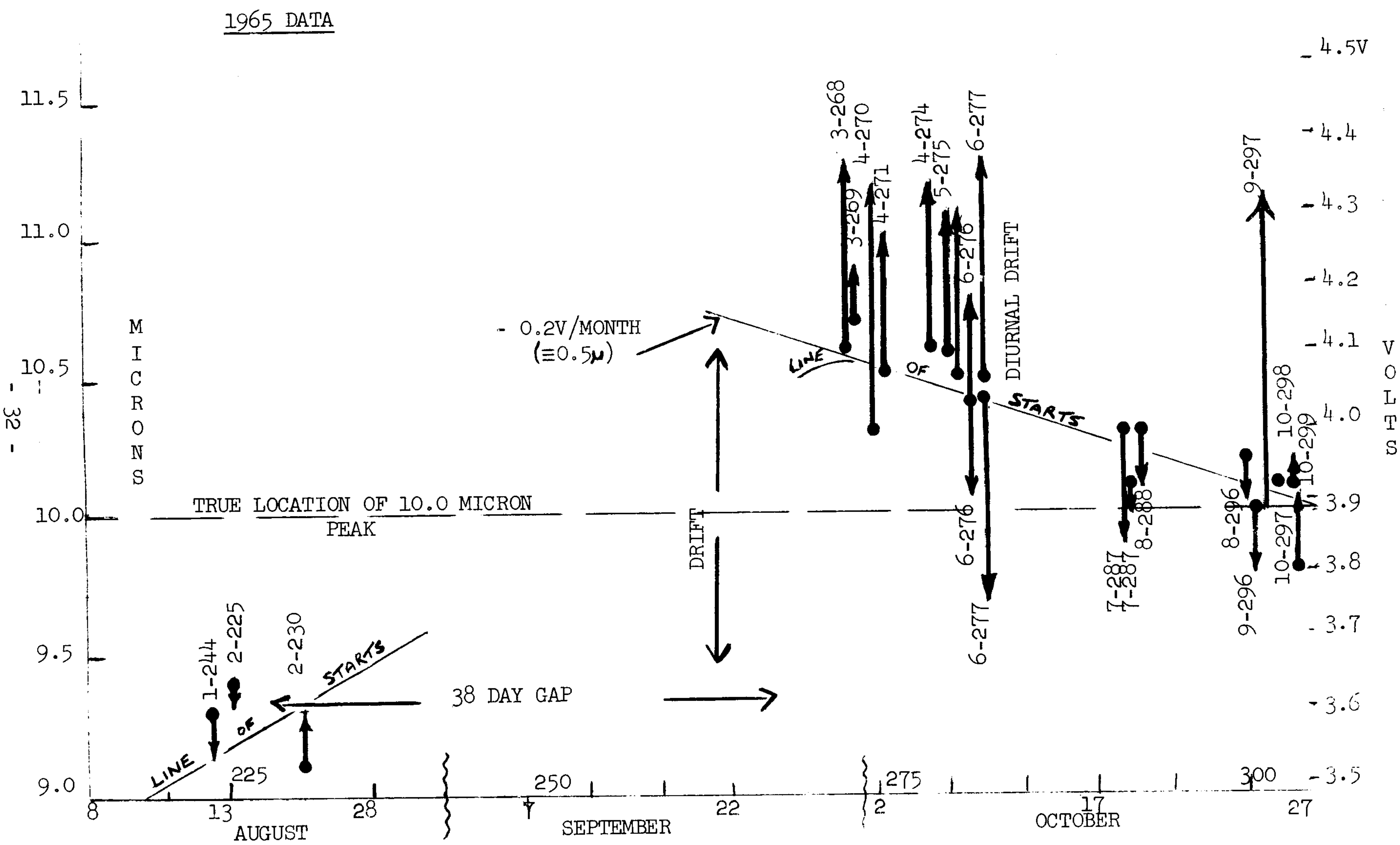


Figure 2 RECORDER-INDUCED "DRIFT" OF 10.0 MICRON PEAK OF FILTER #4 (AMPEX SP-300)

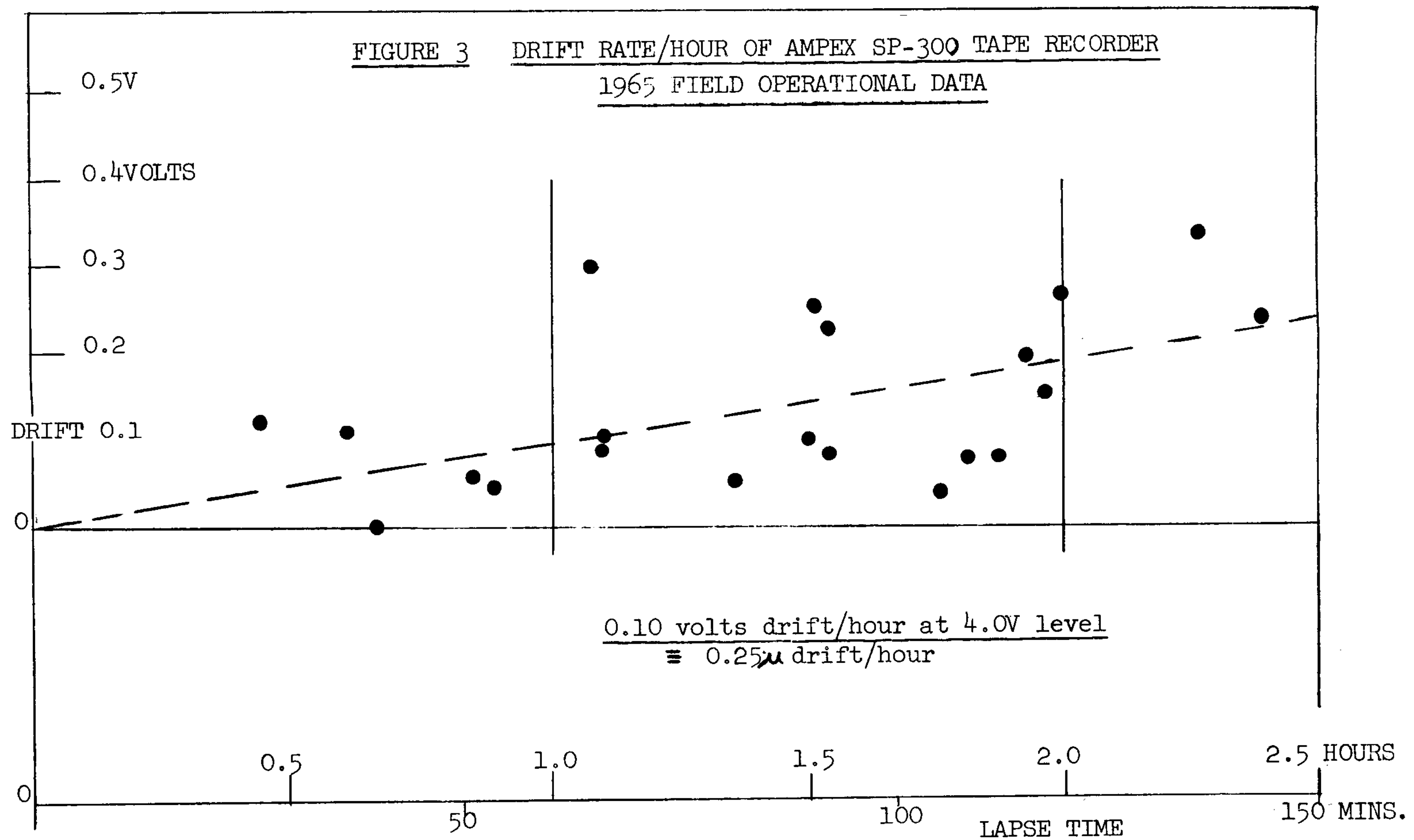


FIGURE 3 DRIFT RATE/HOUR OF AMPEX SP-300 TAPE RECORDER
1965 FIELD OPERATIONAL DATA
0.5V
0.4VOLTS
0.3
0.2
DRIFT 0.1
0
0.10 volts drift/hour at 4.0V level
≡ 0.25µ drift/hour
0
0.5
1.0
1.5
2.0
2.5 HOURS
50
100
150 MINS.
LAPSE TIME

FIGURE 3

TABLE II SPECTRA NOISY BEFORE RECORDING

(Noted from Polaroid prints made before tape recording commenced)

TAPE #	GOOD	PARTLY NOISY	NOISY	V. NOISY	TOTAL TAPE
1	5 (63%)	3 (37%)			8
2	1 (6%)	2 (9%)	7 (33%)	11 (52%)	21
3	2 (12%)	9 (53%)	6 (35%)		17
4	11 (21%)	6 (11%)	19 (37%)	16 (31%)	52
5	9 (28%)	13 (41%)	10 (31%)		32
6	9 (31%)	5 (17%)	5 (52%)		29
7		3 (11%)	14 (50%)	11 (39%)	28
8			5 (23%)	17 (17%)	22
9		3 (9%)	14 (41%)	17 (50%)	34
10	1 (2%)	1 (2%)	10 (27%)	25 (69%)	37
TOTALS	38 (13%)	45 (16%)	100 (36%)	97 (35%)	280

FIG.4

NOISE PRESENT

ON

POLAROID PRINTS

PRE-TAPE

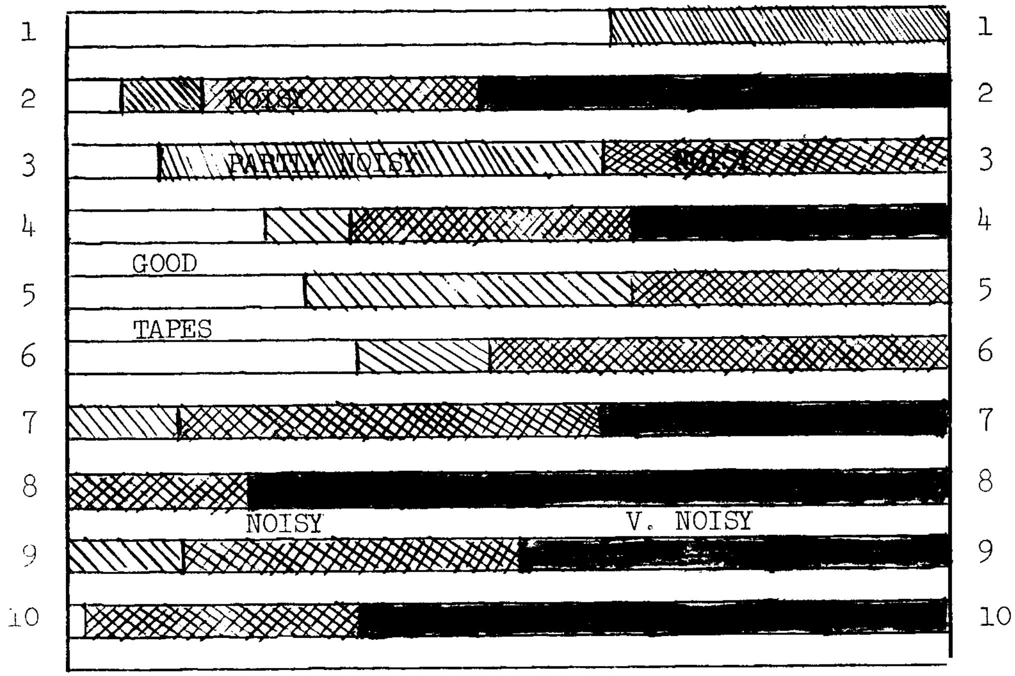


TABLE III STATUS OF NOISE ON POLAROID PHOTOS OF FIELD SPECTRA

O.K.	Noisy Partly	Noisy	Very Noisy
Pacific Grove (PGLH01) 101, 102, 103, 104, 105 NO TAPE LEFT	106, 107, 108		
(PGLP02) NO TAPE	201, 202		203, 204, 205, 206, 207, 208, 209, (211) (212)(213)
Donner Pass (DP6C01) 214 NO TAPE LEFT		(215) 216 (217) 218,219 (220) (221)	
Mono Craters (MCAB01) 309 310	301, 302	303, 304, 305, 306 307, (308?)	
(MSC01) NO TAPE LEFT	311, 312, 313, (314) 315, 316, 317	451	452, 453
(MSC05) (New day)			401, 402, 403, 404, 405 406, (407)(408) 409 410, 411
	(?Noise Changes)	412, 413, (414) 415, 416, 417	418
(MCNC01) New Site/day	419,420, 421 422, 423, (3cps)	424, 425	426, 427 "boiling"-refilled
432 (upright target)	428	429, 430, 431	
New Day		433 (2cps) 434, 435, (436)(437)(438)(439)	

( ) See over

TABLE III (Continued)

O.K.	Noisy Partly	Noisy	Very Noisy
440, 441, 442, 443, (444) 445, 446, 447, (448) 449			
(MCCC01) 502, 503, 504, 505 NO TAPE	501 506, 507, 508, 509 510, 511, 512	513, 514, 515, 516 517	
(MCSC05) 518, (519) 520, 521 (522) NO TAPE	523, 524, (525) (526) 527	528, (529) 530 (531) (532)	
(MESC05) (Same site/Day, new tape)	601, 602, 603	604, 605 (new site)	
(MCSC10) 606 (607) 608, 609, 610 (611) (612) 613, 614	(615) (616) (no 617-620)		
(MCSB01)		621, 622, 623 (624) 625 (626) 627, 628 629, 630	
(MCSF01)		(631) 632 (633)	
Tioga Pass (TPOP01) (New day)	709, 710, 711	701, 702, 703, 704 712, 713	705 (706) 707, 708 714
New site (TPLD01)		715, 716, 717, 718 719, 720, 721, 722	723(724)(725)(726)(727)728

( ) see over

TABLE III (Continued)

O.K.	Noisy Partly	Noisy	Very Noisy
Mono Craters (MCBP01)	(New day)	(801) 802	803, 804, 805 (806) 807 (808) 809, 810, (811) (812) 813, 814 (new site)
Pisgah (PCWR01)	(New day)	815, 816, 817	(818) (819) (820) (821) (822)
Pisgah (PCWR02)	(new tape, same day/site) (901) (902) (903)	904 (905) (906)	
Pisgah (PCWR03)		(907)(908)(909)(910) (911)(912)(913)	
Pisgah (PCTP01)	(Refilled helium)	(914) (924)(925)(926)	915, 916, 917,(918) (919) (920)(921)(922)(923) 927, 928 (929)(930)(931) (932)(933)(934)
Pisgah PCER OL, 02	(new tape)	(1001)(1002)(1003) (1004)(1005)(1006)	1007 New day
Pisgah (PCLL12) New day			1008 1009 (1010)(1011) (1012)(1013)(1014)(1015)
Pisgah (PCLL13)			(1016)(1017)(1018)(1019) (1020)(1021)(1022)(1023) (1024)
Pisgah (PCLL14)			(1025)(1026)(1027)(1028) (1029)(1030)(1031)
Pisgah (PCLL15) new day 1032	1033	1034 (1035) 1036 (1037)	

( ) means a Polaroid print was not made, hence data is considered to be unchanged.

B. Correction Programming

(1) Usage of Fixed Start & Stop Wavelength

From a study of the plots of radiance versus wavelength it was noted that the order-sorting (optical) filter had maximum peak at 10.0 microns. Due to the VCO drift superimposed on all the 1965 data this peak appears at various (but sequentially and daily increasing values rising from 9.8 to 11.3 microns between August and November 1965. (See previous figure)

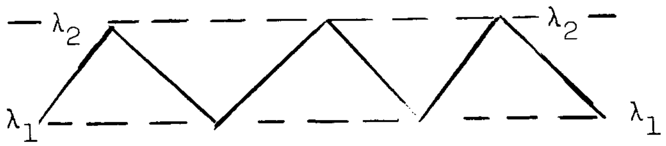
To correct this drift we first observe that the grating in the spectrometer starts at a fixed wavelength and stops at a fixed wavelength for every spectrum. Thus the actual wavelength is known for the minimum voltage for a minimum wavelength and maximum voltage for a maximum wavelength. We also assume that both the wavelength and radiance channels drift by the same amount, and that little drift occurs during one spectrum.

In consequence of the above observations we consider the problem as follows:

Let λ represent true wavelengths

Let λ' represent measured wavelengths

also



Let λ_2 be the highest wavelength, and

λ_1 be the lowest wavelength,

then the true wavelengths are related to the measured wavelengths by

$$\frac{\lambda - \lambda_1}{\lambda_2 - \lambda_1} = \frac{\lambda' - \lambda_1'}{\lambda_2' - \lambda_1'}$$

or

$$\lambda = \frac{(\lambda_2 - \lambda_1)}{(\lambda_2' - \lambda_1')} (\lambda' - \lambda_1') + \lambda_1$$

$$= \frac{(12.77 - 7.52)}{(\lambda_2' - \lambda_1')} (\lambda' - \lambda_1') + 7.52$$

where λ_1' and λ_2' are the measured wavelengths at the top and bottom of the spectrum. λ' is the measured value of the wavelength at the time desired.

For radiance channel corrections we assumed that the voltage drift is the same for the radiance channel as for the wavelength channel. Now the radiance error is known at the top and bottom of the spectrum

$$\Delta E_1 = \frac{V_{\lambda_1}}{V_{E_1}} \bullet \frac{E_1'}{\lambda_1'} \bullet \Delta\lambda_1$$

$$\Delta E_2 = \frac{V_{\lambda_2}}{V_{E_2}} \bullet \frac{E_2'}{\lambda_2'} \bullet \Delta\lambda_2$$

where V_{λ_1} etc. are the voltages on the magnetic tape corresponding to wavelength or radiance at positions 1 or 2.

Thus true radiance is computed by

$$E = E' + \Delta E_1 + \frac{\lambda - 7.52}{12.77 - 7.52} \quad (\Delta E_2 - \Delta E_1)$$

The procedure for correcting the drift is as follows:

The start and stop times of the desired spectrums are determined from the paper analog readout scrolls, or more recently from the digital tape "dump" itself.

These start and stop times, input to the program, must be the times of maximum and minimum voltage. This differs from that previously, in that before if a shortened spectrum was desired, a later start time was specified and the voltage read off the tape determined the starting wavelength. Now, if a shortened spectrum is desired, a special control variable - IIN - is input to the program. This integer variable has the value of the i^{th} wavelength where the spectrum is to start. In example,

if IIN = 0 or 1 the spectrum starts at 7.8,

if IIN = 2 the spectrum starts at 7.9,

if IIN = 3 the spectrum starts at 8.0, and so on.

(2) Wavelength Shift Programming

a. Generation of Shifted Card Output

A short program (SHIFT) was written to accept the card output from the Main Program (NSCP) containing data for average blackbody radiance, average emittance or emittance ratio. The program shifts this data by a specified amount (microns) and generates a new set of cards containing the shifted data.

The input cards in the shift program are in the same order as they are generated from the main program with the exception of an additional shift card placed before each set of nine cards specifying the amount of shift. The amount of shift is specified by a floating point number, whose absolute value is less than that placed in columns 1 through 10 of the shift card.

Recall that there is a run identification card generated by the main program for each run. This card must be the first card in the input to the shift program. Suppose that data from two different runs were to be processed in one run of the shift program. In this case a card containing a floating point ten (i.e. 10.0) anywhere in columns one through ten must be placed between the data from each run (i.e. just before the run identification card). Hence the following sequence of cards is typical input to the shift program:

1. Run identification card - Run #A
2. Shift card for 1st set of data - (FORMAT (F10.5))
3. Data identification card - Data Set #A1
4. Eight data cards (in sequence)
5. Shift card for 2nd set of data
6. Data identification card - Data Set #A2
7. Eight data cards
8. Floating point 10.0 in columns 1-10
9. Run identification card - Run #B
10. Shift card for 1st set of data in Run #B
11. Data identification card - Data Set #B1
12. Eight data cards

etc.

The output consisted of a set of punched cards containing the shifted data, 53 points per set in the same format as the input.

Printed output is also given.

It should be noted that the integer values for I1 and I2 punched in the data identification card in columns 13-15 and 16-18 are used during the shifting operation. Only those points between I1 and I2 (inclusive) are shifted by the specified amounts all other values are considered as zero.

b. Main Program Usage with New Entry Points

A new version of the main program, NSCP, has been developed with facility for accepting data from cards for average blackbody radiance and average emittance or emittance ratio. The card format required is the same as that generated by the data SHIFT program.

There are two possible re-entry points in the main program. At entry point A, a set of average blackbody radiance data (9 cards) and sets of average emittance data (one 9-card set for each sample spectra) are read in. Emittance ratios are then computed for each sample spectra from this data, correlation coefficients are computed and plot and card output generated. At entry point B, a set of emittance ratios (9 cards) are read in for each sample spectra. Correlation coefficients are then computed from this data and plot and card output are generated.

The input data format for entry A and entry B is identical to the output data format for the SHIFT program with the exception of one additional card. The first data card is a run identification card - this may be the same identification card generated by the SHIFT program. The second card contains four control variables. They are specified with format (4I5) in the following order:

NISSP - number of sample spectra

JUMP - for JUMP < 0 Entry A is executed (i.e. average emittance data is read)

- for JUMP > 0 Entry B is executed (i.e. emittance ratios are read)

IDTST - tape number (for identification)

KPLOT - for KPLOT > 0 no plots are generated
for KPLOT = 0 all plots are generated
for KPLOT < 0 only emittance ratio plots are generated.

The remainder of the data depends on the entry point specified. If entry point A is specified, blackbody data and average emittances are read in and if entry B is specified, emittance ratios are read in. The format of this data is identical to the format of the card output from SHIFT, i.e. sets of 9 cards, the first card being a data identification card and the last eight cards containing 53 values, with seven per card (FORMAT (1X, 7 F 10.5)) except for the last card which contains 4 values (FORMAT (1X, 4F 10.5)).

The following sequence of cards would constitute a typical set of input data:

1. Run identification card - can be the same as the one generated by SHIFT.
2. Re-entry control card with NISSP, JUMP, IDTST and KPLOT specified. For this case NISSP = 2 and JUMP = 0.
3. Blackbody Radiance data identification card.
4. Eight cards with average blackbody radiance data (53 values).
5. Data identification card - average emittance data for first sample spectra.
6. Average emittance data for the first sample spectra - (53 values).
7. Same as 5 for the second spectra.
8. Same as 6 for the second spectra.
9. Run identification card - for second run.
10. Re-entry control card for second run. For this case NISSP = 2 and JUMP = 1.
11. Data Identification Card - emittance ratio data for the first sample spectra.
12. Emittance ratios for the first sample spectra (53 values)
13. Same as 11 for second sample spectra.
14. Same as 12 for second sample spectra.

C. TAPE DUMP PROGRAM

The TRIFID data tapes are written in a closely packed binary form. As indicated previously, 3 words of wavelength and radiance are packed into one computer word. The TRIFID tapes are also blocked, that is 255 computer words are written onto one physical record of the tape. An inter-record gap occurs on the tape between each of these physical records. The last word of each physical record contains a range-coded time (Pacific Missile Range Time). It is assumed, to relate the wavelengths and radiances to a unique time, that each set of one wavelength observation and one radiance observation occurs at a time computed by a linear interpolation between the two range coded times of two successive records. Thus 254 computer words of packed wavelength and radiance, plus one time, occur per record. This gives 254 x 3 or 762 words of wavelength and radiance or 381 sets of observations per record. These observations occur continuously and succesively down the tape. In order to find a particular spectrum, two range coded times are required - the start of the spectrum and the stop of the spectrum.

The spectrum is found by searching the tape until a range coded time in the last word of a record exceeds a start time. If so the record is saved and the start wavelength and radiance are bound by interpolation between this range coded time and the range coded time of the previous record.

Difficulty was encounted in determining the start and stop times of spectra. The computer program uses the information directly from the TRIFID tapes which were digitized from the original field analog tapes. This time information, because of noise, may not necessarily agree with that on analog scrolls which were used previously to manually determine range-coded times. In addition the analog scrolls were hard to read with precision since the observer had to perform interpretive measurements which were subject to error in order to determine the start-stop times. It was therefore decided to write a program to dump the basis TRIFID tapes with range coded times in a format that could be easily read.

A program was written which used the basic LMSC search package. The program reads a record, completes range coded times for each observation set by interpolating between the times in two successive record, and prints out the time, wavelength and radiance for each observation. Thus one can scan down the listing until a minimum in wavelength occurs, conclude that this is a start of a spectral interval, and copy down the range coded time of the minimum wavelength.

There is a facility in the tape dump program for listing only a desired set of records. For example, instruction can be given to start listing at the 23rd record and stop at the 37th record.

The format of the input cards to the program are as follows:

(2F10.5) REC, START

REC is the total number of records to be read and listed

REC is placed in floating point form on the first 10 columns of the card e.g., 37.0. If REC is zero or blanks, the program assumes a value of 1000.0

START is the number of the record at which listing is to begin

START is placed in floating point form in the second 10 columns of the card e.g., 23.0. If START is zero or blanks, listing starts with the first record

The TRIFID tape is mounted on logical unit 12. This corresponds to physical unit B7 on the Stanford 7090.

<u>A TYPICAL OUTPUT TAPE DUMP PROGRAM</u>

NASA SPECTRA CORRELATION TAPE DUMP

5 SETS OF DATA PRINTED PER LINE

NREC = 1000

TAPE INDICATIVES
0000000000 0 12 0000000

Record 1

		Time	Radiance	Wavelgth																				
0	6	57.840	1092	1109	0	6	57.869	1084	1102	0	6	57.897	1089	1106	0	6	57.926	1086	1103	0	6	57.954	1089	1104
0	6	57.982	1094	1110	0	6	58.011	1081	1099	0	6	58.039	1083	1100	0	6	58.067	1085	1105	0	6	58.096	1086	1101
0	6	58.124	1082	1101	0	6	58.153	1082	1099	0	6	58.181	1074	1091	0	6	58.209	1081	1099	0	6	58.238	1087	1101

Key

(0 hrs. 6 mins. 58.124 secs.)